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(54) Position detecting device and its method

(57) A device for detecting position which has a good S/N performance and which can be easily designed is provided. Said device has the feature of: a plurality of antennae in which three or more turns of loop coils are arranged in parallel; a transmitting circuit for transmitting an electromagnetic wave via one of the antennae; a receiving circuit for receiving a responding electromagnetic wave from the position indicator; a selecting circuit for selecting one of the antennae; a transmitting/receiving switch circuit for connecting the selected antenna to either of said transmitting circuit or said receiving circuit; a connecting control circuit for controlling operations of

the selecting circuit and the transmitting circuit; and a discriminator circuit for discriminating the position and the state of said switch based upon the characteristics of a signal received to send the discriminated information. Said connecting control circuit selects an antenna predicted to be the most proximate antenna to said position indicator during transmission operation of the indicator; and controls such that each of said antennae is sequentially selected to be scanned for reception during receiving operation.

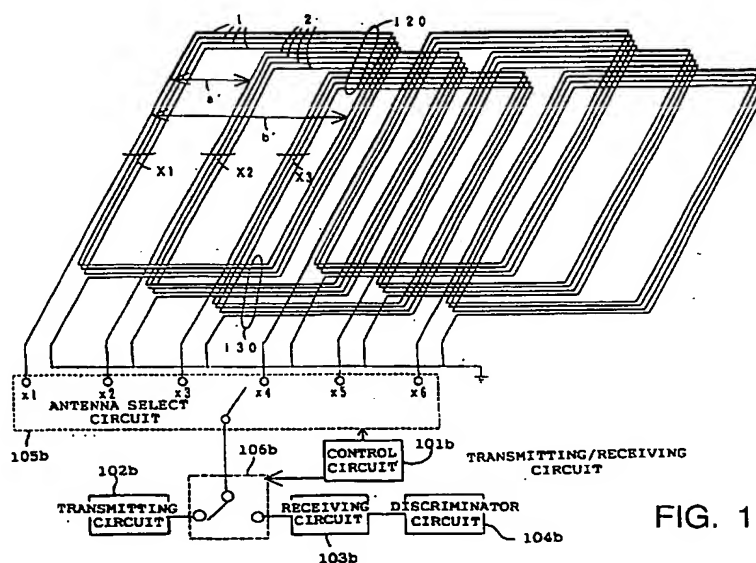


FIG. 1

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a position detecting device having a cordless position indicator and its method.

2. Description of Prior Art

There is an electromagnetic transceiver system that is a method of position detecting for digitizers. This has an arrangement including, for example, a position detecting plane in which a large number of loop coils are disposed in parallel, with a position indicator such as a pen or a cursor display, wherein the loop coils are respectively used as sensors i.e. antennae, by utilizing electromagnetic interaction generated between the loop coils and the position indicator to transmit and receive electromagnetic waves between them. Based upon resulting signals detected therefrom, the system retrieves coordinate information of the indicator itself as well as other information. Through this system could be provided a principle feature. That is, that the position indicator is of a cordless system. The present applicant has proposed several digitizers in accordance with this method of electromagnetic transceiver system in Japanese Patent Gazette No. H2 (1990)- 53805, and Japanese Patent Application Laying- Open No. H3 (1991)-147012. One of the principal objects in these Patent and Patent applications is how to retrieve information from a received signal which is free from noise and at high speed.

In the method of electromagnetic transceiver system, for example, a transceiver operation is performed in which one of the antennae is sequentially selected for transmitting an electromagnetic wave and also receiving the electromagnetic wave reflected back from a resonance circuit or coil disposed within the position indicator via the selected antenna, and an arithmetic operation is performed which includes interpolation based upon the signals received via antenna which is predicted to be the strongest receiving signal and its adjacent antennas for determining the coordinate of the position indicator.

For obtaining accurate coordinate information, it is effective to place a number of antennas close to one another. But it makes the switch needed to select one of the antennae and associated control means large and complex. Therefore, it is desirable to perform detection operation with a decreased number of antennae and still with accuracy.

In the method mentioned above, the electromagnetic waves radiating back from the position indicator have very weak energy so that they cause the detection to be difficult, and if the position indicator is remotely positioned from the position detecting plane, the detection is made even more difficult. Therefore, various kinds of measures against noise are proposed by utilizing a

high performance amplifier, or a low noise level signal processor, but the improvement of S/N requires a very sophisticated technique, or makes the structure more complicated and hence adds to costs.

Furthermore, applications wherein the position detecting device is equipped within the display portion of the computer, e.g. a so called "pen computer", in combination with a liquid crystal display, have come into wide use recently. When the device is used in such a high noise circumstance, more powerful anti-noise characteristics are required. Also, when the device is used in combination with the liquid crystal display, the position indicator and the sensors are required to interact with each other with positioning the liquid crystal display between them since the sensors of the detecting device are disposed beneath the liquid crystal display. Therefore, it is necessary that the functionally allowable detection level of the position indicator be set higher than that of the normal position indicator. The difficulty is however increased further when the detectable level of the position detector is set higher since the signal becomes weaker in accordance with this fact. In addition, the thickness of the liquid crystal display is increasing as the recent colorization and TFT (thin film transistor) application is increasingly adapted. Accordingly, such a system is highly desired, having improved S/N performance.

Generally two groups of antennae, having the same structure to obtain two dimensional coordinate information are disposed, overlapping each other in both X and Y axes directions on the position detecting plane. For practical fabrication of these groups of antennae, the printed wiring board technique is used. Since one group of antennae is required for each of two directions (X and Y axes), a corresponding wiring pattern is provided on each layer of a two-layered printed wiring board. Each of the groups of antennae of X and Y axes has a pattern which is formed by a number of loop coils arranged in parallel on the board, each of the loop coils having folded portions, and a pattern for one axis is placed such that the folded portions of the other loop coils, which forms the pattern of the other axis, come to the inside of the former pattern. This minimizes the ineffective area, wherein no coordinate information for both X and Y axes is provided, so that the position detecting plane can be most effectively utilized. Select terminals for transmitting/receiving signals to loop coils X1, X2,... Xn, which form a group of antennae, are shown in Fig.2 respectively with x1, x2,... xn. The operation of a signal transmitting/receiving and antenna selecting circuit 102a, and a transmitting/receiving switching circuit 105a are controlled by a control circuit 101a. As shown in Fig.2, when the select terminal x6 is selected for example, the transmitting circuit 102a is firstly connected to the switching circuit 105a for sending transmission signal to loop coil x6, then the transmitting/receiving switch circuit 106a is switched to a receiving circuit 103a. As a result of the transmitting/receiving electromagnetic wave between the loop coil x6 and the position indicator, a receiving signal is generated on the loop coil x6, which is supplied to

the receiving circuit 103a via the select terminal x6. Thereafter, the receiving signal is suitably processed to analyze the information included within its amplitude and phase in a discrimination circuit 104a. The transmitting/receiving operation of the respective loop coil is sequentially performed on the loop coils x1 - xn.

In the above mentioned operation, it is known that the loop coil for transmitting or receiving electromagnetic wave operates more effectively as the number of turns of the coil becomes larger. Even when the current of the transmitting signal is not changed, an increment in the number of turns make an increment of strength of the transmitting electromagnetic wave in proportion to the number of turns. The same is also true with increased signal strength in receiving in proportion to the number of turn even when the strength of receiving signal is not changed. Particularly, as in the above mentioned patent application, the system in which the loop coil is commonly used as the transmitting and receiving antenna, can provide an increased efficiency both in the transmission and the reception so that it has an excellent S/N performance.

However, as shown in Fig. 2, the number of turns in each of the loop coils is practically limited to a maximum of two. The reason is that the folded portions of the loop coils forming a pattern of one coordinate is required to be located within the antenna pattern of the other coordinate as mentioned above in order to minimize the ineffective area. Referring to Fig. 2, the folded portions of loop coils X1 and X 2 are designated with 1 and 2, respectively. In this description, each interval between loop coils disposed adjacent each other, (that is, the layout interval), is designated "a", and the width of each loop coil is designated "b" as parameters which show the layouts of the loop coils.

Fig. 3 shows that the folded portions of each of the loop coils are put within the pattern for the other axis of coordinate. In Fig. 3, the patterns are designed so that the folded portions at the select terminals side of the loop coils X1, X2,... X14, arranged in the direction of the X axis, are all put within an interval "a1" between the loop coil Y1 and the loop coil Y2, which are disposed at the underside end among the loop coils arranged in the direction of the Y axis. In addition, the patterns are designed so that the folded portions located opposite to the select terminal side of the loop coils X1, X2,... X14 are all put within an interval "a2" between the loop coil Y10 and the loop coil Y11. Further, the patterns are designed so that the folded portions located opposite to the select terminal of the loop coils Y1, Y2,... Y11, arranged in the direction of the Y axis are all put within an interval "a3" between the loop coil X1 and the loop coil X2, which are disposed at the distal end of the loop coils arranged in the direction of the X axis. In addition, the patterns are designed so that the folded portions at the select terminal side of the loop coils Y1, Y2, Y11, are all put within an interval "a4", between the loop coil X13 and the loop coil X14.

As apparent from the above description, all folded portions of the loop coils for one axis are required to be located within one of the layout intervals of the loop coils for the other axis. There also exists such a case where the folded portions of the loop coils of one axis are forced to arrange utilizing twice the portions of the layout interval of the loop coils of the other axis. In any case, it is clear that difficulty may arise in simply increasing the number of turns of loop coils since the complicated pattern design is required in order to locate every folded portion of a number of loop coils within the layout interval of a limited size. As the number of turns is increased, the number of patterns is also increased in proportion to the number of overlapped coils between adjacent loop coils. In Fig. 3, it is clear that up to 5 loop coils, such as the loop coils X1 to X5 (i.e. the number of overlaps is 5) are overlapped together, and the area where the greatest running number of folded portions exists, needs 2 x 5 wirings, in total 10 wirings. (For example, the portions designated by the numerals 100 and 110 as shown in Fig. 3). Therefore, not only the number of patterns themselves, but also the numbers of connecting portions, (such as through-holes), increased so that the number of turns are limited to 2 in prior arts.

Of course, if a multilayer printed wiring board is employed rather than a double layer printed wiring board, the number of turns can be increased further. However, in that case, the cost problem become significant, which makes the product impractical.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a position detecting device having good S/N characteristics by increasing the number of turns of loop coils of antenna for transmitting/receiving electromagnetic waves in the position detecting device.

It is a further object of the present invention to provide a position detecting device having antenna patterns, which can be simply formed at a low cost without increasing any difficulties in designing the pattern even when the number of turns of loop coils is increased.

For accomplishing the above mentioned objective, the present invention provides an innovative scanning method for scanning a lot of loop coils, wherein it provides a means for separately selecting a antenna in transmission and reception, while conventionally, a paired transmission and receiving operation is performed with one selected antenna in the sequentially scanning manner. In a preferred embodiment of the present invention, a method is provided in which, firstly, in transmission an antenna is always selected which is predicted to be the most proximate antenna to a position indicator. Via said antenna, a signal is then transmitted to said position indicator, and all antennae are scanned to get signal characteristic distribution required for a coordinate detection in receiving the electromagnetic waves reflected back from the position indicator due to

the electromagnetic interaction effect between them in response to the transmitted signal.

According to the scanning method of the present invention, an advantage can be attained, as the distance between the position indicator and the antenna is being increased while maintaining the ability to receive substantially the same strength of electromagnetic wave. That is, according to the new scanning method of the present invention, the detectable electromagnetic wave from the position indicator can be reached to more remote area than that of the prior art.

Thereby, the present invention provides, an increased layout interval between antennae than the prior art resulting in a reduced number of antennae. This also means that the number of overlaps of the loop coils can be reduced so that it gives sufficient room for disposing folded portions of the loop coils respectively forming the antennae. Utilizing the space allows an antenna pattern with an increased number of turns than the prior art.

In another embodiment of the antenna scanning method of the present invention, scanning is performed for all of the antennae during the transmission period which is required in detecting the coordinates of an object, and the most proximate antenna to the position detector may be selected for receiving an electromagnetic wave in regard to receiving an electromagnetic wave generated by the electromagnetic interaction effect between the respective antenna and the position indicator.

The present invention provides a new scanning method for transmitting and receiving as mentioned above, which allows room in designing the antenna pattern. Thus, the number of turns of the loop coils forming the antenna can be increased, which in turn increases the efficiency of the antennas and, can prove significantly increased S/N performance.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic diagram showing an arrangement of an embodiment of a position detecting device according to the present invention;

Fig. 2 is a schematic diagram showing an arrangement of an illustrative exemplification of a position detecting device of the prior art;

Fig. 3 is a plan showing two pairs of antennae orthogonally disposed to each other such that each of the folded portions of loop coils becomes located within a respective pattern of loop coils of the other axis;

Fig. 4 shows illustrative views of scanning methods of antennae of a prior art example a) and the embodiment b) of the present invention during the transmission and reception periods; and

Fig. 5 is a graphical representation of the characteristic curve 5 of the strength of receiving signals of the prior art a) and the embodiment b) according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 is a schematic diagram showing an arrangement of an embodiment of a position detecting device according to the present inventions. In Fig. 1, the loop coils 1 and 2 forming one of antennae have the width "b" which is the same as the width "d" of the loop coils of the example of the prior art mentioned above and shown in Fig. 2, but a layout interval "a" between adjacent loop coils is expanded more than the corresponding layout interval "a" of the prior art shown in Fig. 2. Assuming now that the width "b" of the loop coils is equal to 1, the layout interval "a" of the preferred embodiment of the present invention is equal to 2/5 thereof as shown in Fig. 1, while the layout interval "a" of the prior art is 2/9 as shown in Fig. 2. That is, the layout interval "a" of this preferred embodiment is less than 2 times the interval "a" of the prior art. In addition, the number of overlaps is decreased to 3 (X1, X2, and X3), compared with the number of 5 of overlaps in the prior art. These three folded portions of the antenna are arranged over a single layout interval of the antenna of the other axis. Since the layout interval of the antenna of the other axis is the same "a" which is larger than that of the prior art, the area itself is made larger on which the folded portions are arranged. Therefore, in the preferred embodiment as shown in Fig. 1, the number of turns is increased to 4. In this case, 3 x 4 wirings, that is, 12 wirings are required at the portion where the running number of loop coils are most highly overlapping (the corresponding portions are designated by the numerals 120 and 130 as shown in Fig. 1), but these portions do not raise any problem since the area itself, on which the folded portions are located, are correspondingly made large.

According to the present invention, increasing the maximum allowable number of turns of the antenna can easily be attainable from the two of the prior art to four, that is twofold.

The description will now be made as regard to a method of scanning antennae during transmission and reception period according to the present invention, which allows the layout interval to expand from that of the conventional method. Fig. 4 shows illustrative views of scanning methods of antennae of a prior art example (Fig. 4a) and the embodiment (Fig. 4b) of the present invention. For simplifying the description, a group of antennae comprising a number of antennae are shown with only three antennae A, B, and C. Conventionally, as shown in Fig. 4a, the antenna A is selected to be set to transmission state, and then switched to reception state. A responding electromagnetic wave is produced, caused by an electromagnetic interaction effect between the transmitted electromagnetic wave and a resonant circuit positioned within the position indicator. (1) The responding electromagnetic wave is received with the same antenna A which transmits a received signal to a discriminator circuit 104a via a receiving circuit 103b. (2) Next in similar manner, an antenna B is selected, which

obtains a received signal and sends it to the discriminator circuit 104a. (3) Again in a similar manner, an antenna C is selected, which obtains a receiving signal to the discriminator circuit 104a. In this manner in the prior art, transmission and reception are performed with such a paired operation for the selected antenna. The characteristic curve of strength of the receiving signal obtained via scanning the antennae by the prior art method is shown by a dotted line curve a) in Fig. 5.

While in operation according to the referred embodiment of the method for scanning antennae of the present invention as shown in Fig. 4b, (1) an antenna B is selected which is predicted to be the most proximate antenna to the position indicator, and which is set to transmission state for transmission. A responding electromagnetic wave is produced by an electromagnetic interaction effect between the transmitted electromagnetic wave and the resonant circuit located within the position indicator. Firstly, the antenna A is selected to be set to the receiving state and performs the receiving operation, and sends received signal via the receiver circuit 103b to the discriminator circuit 104b. (2) Next, the antenna B is again set to the transmission state and performs transmitting operations. Then the antenna B is selected to be set to the reception state and performs the receiving operation, and the received signal is sent via the receiving circuit 103b to the discriminator circuit 104b.

(3) Furthermore, the antenna B is again set to the transmission state and performs transmission operation. Then, the antenna C is selected to be set to the receiving state, and the received signal is sent to the discriminator circuit 104b. Thus, according to the embodiment of the method for scanning antenna of the present invention as shown in Fig. 4b, a plurality of groups of antennae is scanned only during the receiving operation, and the transmission operation is always performed via the antenna B which is predicted to be the most proximate antenna to the position indicator. The characteristic curve of strength of the receiving signal, which is obtained by scanning the antennae according to the method of the present invention, is shown by a solid line curve b) in Fig. 5.

As mentioned above, Fig. 5 is a graphical representation of the characteristic curves of the strength of receiving signals obtained by scanning the antennae wherein the curve a) shows a distribution of the strength of the signal according to the prior art method for scanning antenna, and the curve b) shows a distribution of the strength of the signal according to the method for scanning antenna of the present invention. The abscissa shows a relative antenna position, and the center (0) of the coordinate is taken where the maximum signal strength is appearing. It can be seen that the distribution curve b) of the present invention has a broad strength distribution as compared with the prior art curve a), i.e. it has the area of the antenna position of the same signal strength in wider area than that of prior art. This also means that it ensures detection with the same accuracy

as the prior art, even though the antenna layout interval between the antennae is increased more than that of the prior art. As a result of this, an increase of the layout interval between the antennae is attained with to the present invention.

In another embodiment of the present invention, a plurality of groups of antennae is sequentially scanned during transmission, and the reception may always be performed by the antenna which is predicted to be the most proximate antenna to the position indicator. That is, if described with reference to Fig. 4, firstly the transmission is performed via the antenna A and the reception is performed via the antenna B. Next, the transmission is performed via the antenna B and the reception is performed via the antenna B. Furthermore the transmission is performed via the antenna C and the reception is performed via the antenna B.

According to any embodiment mentioned above in detecting the coordinate, the scanning should be done to each of the groups of antennae arranged in the direction of the axis of the coordinate to be detected in regard to the groups of antennae to be scanned, while the scanning may not always be done to the groups of antennae arranged in the direction of the axis of coordinate, in regard to the single antenna which is predicted to be the most proximate antenna to the position indicator. For example, in detecting the X coordinate, in the case where a method is applied wherein a single transmission antenna is fixed, and the receiving antennae are scanned, the antennae to be scanned should be arranged along the direction of the X axis. The single transmission antenna to be fixed is not required to be selected from the groups of antennae arranged in the X axis, but it may be selected from the groups of antennae arranged in the Y axis. Even when an antenna, which belongs to another axis is to be selected as the fixed antenna, it must be the most proximate antenna to the position indicator.

For accomplishing the method of scanning antenna according to the present invention, the device portions including the transmitting/receiving switch circuit associated with the scanning, the control circuit and the like correspond to the method of the present invention. According to the present invention, as described above, the number of antennae can be decreased so that these circuits can be simplified.

According to the present invention, a new scanning method is introduced for the transmission and reception of the groups of antennae of the position detecting device, thereby allowing the layout interval of the antennae to be expanded and the number of antennae to be decreased.

Therefore, the number of circuits for switching the antennae and the units with regard to said circuits such as the control circuit can be simplified and reduced.

The layout interval between the antennas can be expanded to allow an increased number of turns of each antenna. Thereby, S/N of the device can be greatly improved so that the units such as a receiving circuit, a

signal processing circuit and the like are significantly simplified. The combination with a liquid crystal display can be attained by using the present invention rather than that of the prior art since the detecting performance has been greatly improved.

Claims

1. A position detecting device comprising a resonant circuit and a cordless position indicator in which at least one switch is mounted, wherein said position detecting device includes:
 - a plurality of antennae arranged in parallel in a direction of detecting position at a predetermined interval and partly overlapping each other;
 - a transmitting circuit for transmitting an electromagnetic wave, which has a proximate frequency to the resonance frequency of said resonant circuit located within said position indicator via one of said antennae;
 - a receiving circuit for receiving via said one of antennas a responding electromagnetic wave which is produced by an electromagnetic interaction effect between said electromagnetic wave and said resonant circuit;
 - a selecting circuit for selecting one of said antennae;
 - a transmitting and receiving switch circuit for connecting said selected antenna to either of said transmitting circuit or said receiving circuit;
 - a connecting control circuit for controlling operations of said selecting circuit and said transmitting circuit; and
 - a discriminator circuit for discriminating the position of said position indicator and the state of said switch based upon the characteristics and distributing state of a signal received by said receiving circuit and transmitting information derived from said signal to an associated upper information processing device;
 - said connecting control circuit selects an antenna predicted to be the most proximate antenna to said position indicator during transmission operation of the indicator, and controls such that each of said antennae is sequentially selected to be scanned for reception during receiving operation.
2. A position detecting device comprising a resonant circuit and a cordless position indicator in which at least one switch is mounted, wherein said position detecting device includes:
 - a plurality of antennae arranged in parallel in a direction of detecting position at a predetermined interval and partly overlapping each other;
 - a transmitting circuit for transmitting an electromagnetic wave, which has a proximate frequency to the resonance frequency of said resonant circuit located within said position indicator via one of said antennae;
 - a receiving circuit for receiving via said one of the antennae a responding electromagnetic wave which is produced by an electromagnetic interaction effect between said electromagnetic wave and said resonant circuit;
 - a selecting circuit for selecting one of said antennae;
 - a transmitting and receiving switch circuit for connecting said selected antenna to either of said transmitting circuit or said receiving circuit;
 - a connecting control circuit for controlling operations of said selecting circuit and said transmitting circuit; and
 - a discriminator circuit for discriminating the position of said position indicator and the state of said switch based upon the characteristics and distributing state of a signal received by said receiving circuit and transmitting information derived from said signal to an associated upper information processing device;
 - said connecting control circuit controls such that each of said antennae is sequentially selected to be scanned for transmission during transmission operation of said position indicator, and selects an antenna predicted to be the most proximate antenna to said position indicator during reception operation.
3. A position detecting device as claimed in claim 1 or 2, wherein each of said antennae is formed with loop coils, the number of turns of which are equal to three or more.
4. A position detecting device as claimed in claim 1, 2, or 3, wherein said antennae are arranged into two groups of antennae and orthogonally disposed with respect to the other;
 - each of said groups of antennae is formed with patterns on a respective layer of a double layer printed wiring board, and folded portions of said patterns of loop coils forming one group of said antennae are disposed within the patterns of loop coils forming the other groups of said antennae.
5. A method for detecting position using a resonant circuit and a cordless position indicator in which at least one switch is mounted, wherein said method comprising the following steps:
 - arranging a plurality of antennae in parallel in a direction of detecting position at a predetermined interval and partly overlapping each other;
 - transmitting an electromagnetic wave, which has a proximate frequency to the resonance frequency of said resonant circuit located within said position indicator via one of said antennae;
 - receiving via said one of antennae a responding electromagnetic wave which is produced by an electromagnetic interaction effect between said electromagnetic wave and said resonant circuit;
 - selecting one of said antennae;

connecting said selected antenna to either of said transmitting circuit or said receiving circuit to switch to transmission or reception operation;

controlling operation of said selecting, and said transmission and reception operation; and

discriminating the position of said position indicator and the state of said switch based upon the characteristics and distributing state of a signal received and transmitting information derived from said signal to an associated upper information processing device;

in said controlling step, selecting an antenna predicted to be the most proximate antenna to said position indicator during transmission operation of the indicator, and controls such that each of said antennae is sequentially selected to be scanned for reception during receiving operation.

6. A method for detecting position using a resonant circuit and a cordless position indicator in which at least one switch is mounted, wherein said method comprising the following steps:

arranging a plurality of antennae in parallel in a direction of detecting position at a predetermined interval and partly overlapping each other;

transmitting an electromagnetic wave, which has a proximate frequency to the resonance frequency of said resonant circuit located within said position indicator via one of said antennae;

receiving via said one of the antennae a responding electromagnetic wave which is produced by an electromagnetic interaction effect between said electromagnetic wave and said resonant circuit;

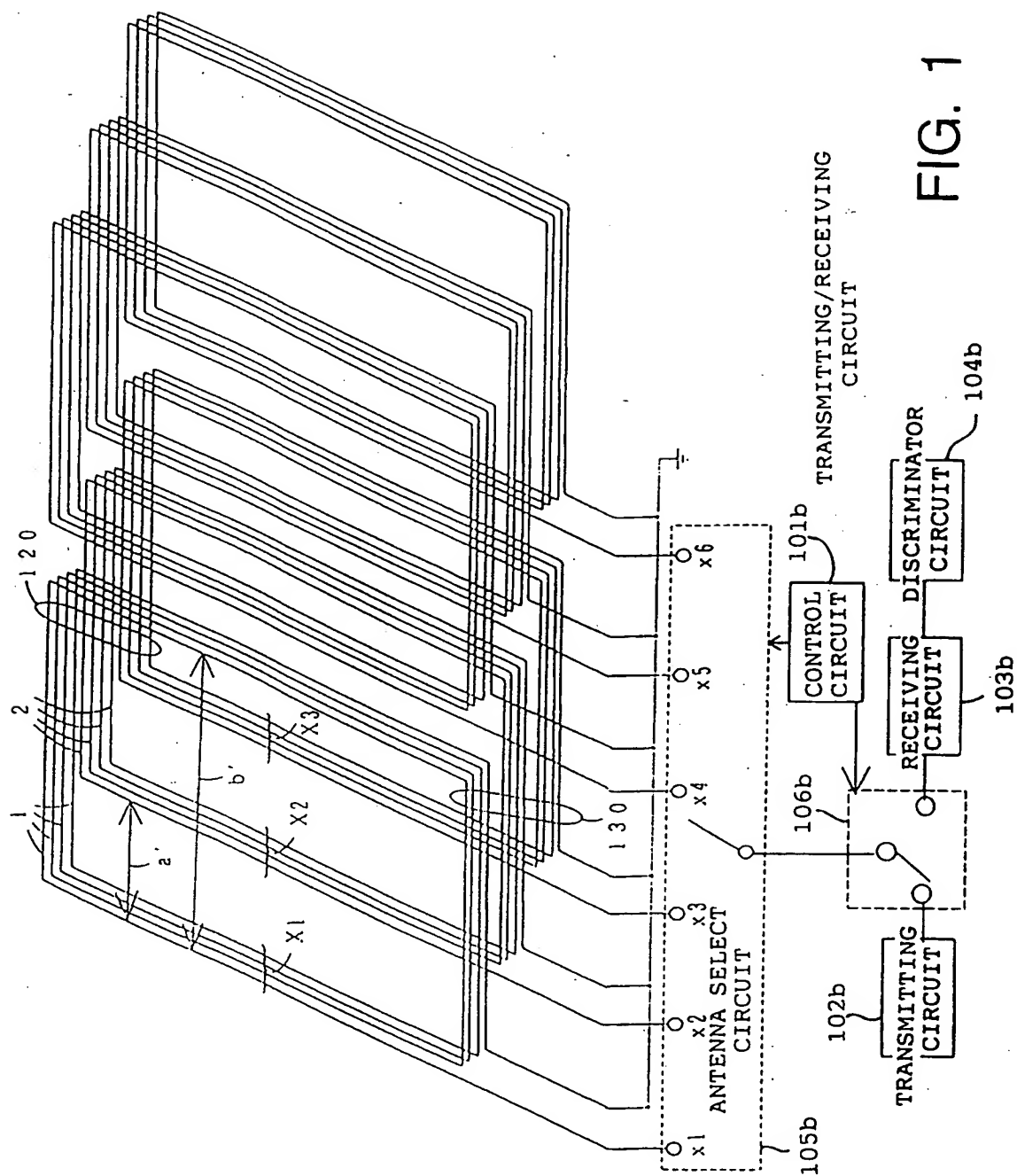
selecting one of said antennae;

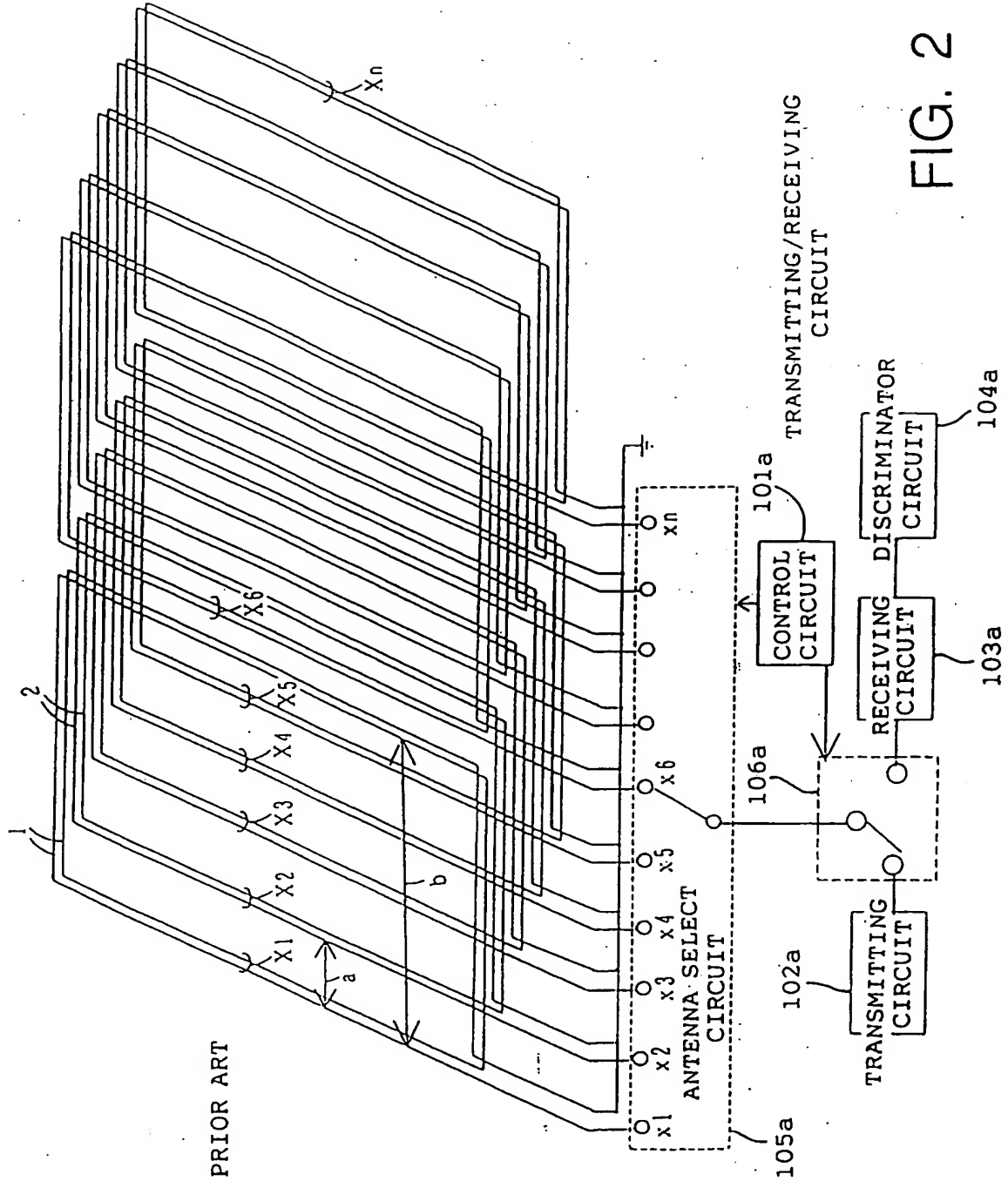
connecting said selected antenna to either of said transmitting circuit or said receiving circuit to switch to transmission or reception operation;

controlling operation of said selecting, and said transmission and reception operation; and

discriminating the position of said position indicator and the state of said switch based upon the characteristics and distributing state of a signal received and transmitting information derived from said signal to an associated upper information processing device;

in said controlling step, each of said antennae is sequentially selected to be scanned for transmission during transmitting operation and selects an antenna predicted to be the most proximate antenna to said position indicator during receiving operation of the indicator.





FOLDED PORTIONS TO BE LOCATED WITHIN ANTENNA OF OTHER AXIS

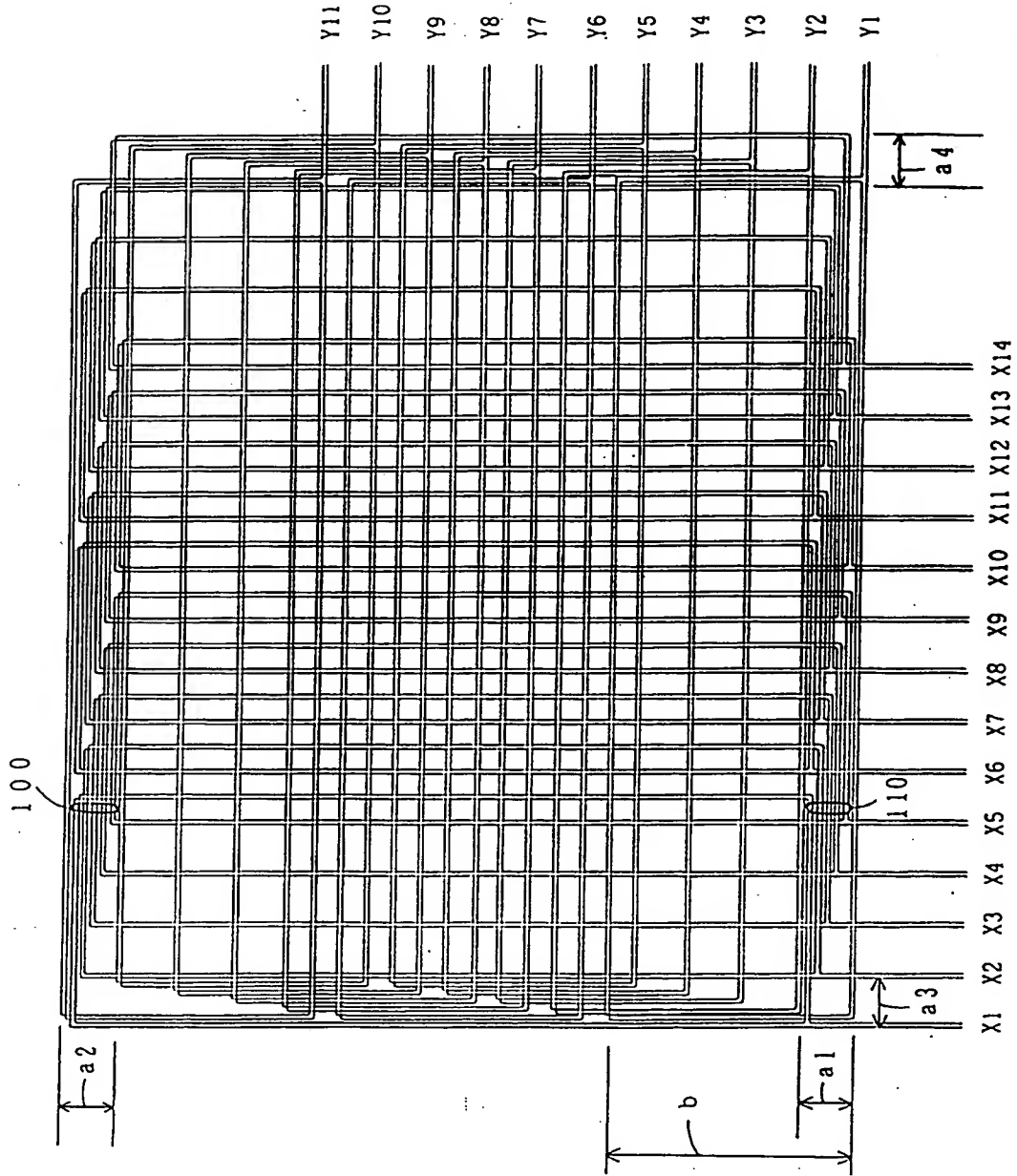


FIG. 3

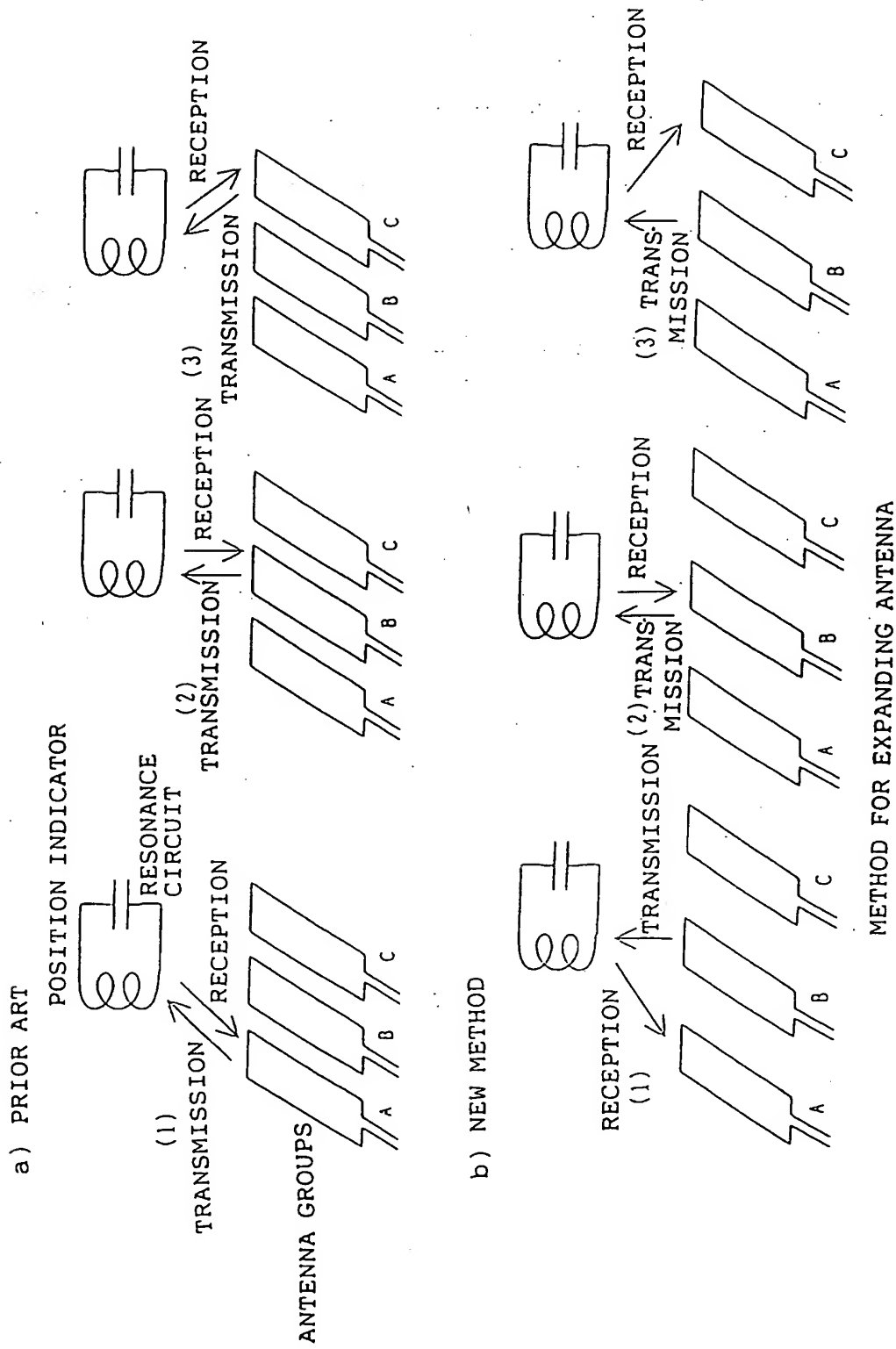


FIG. 4

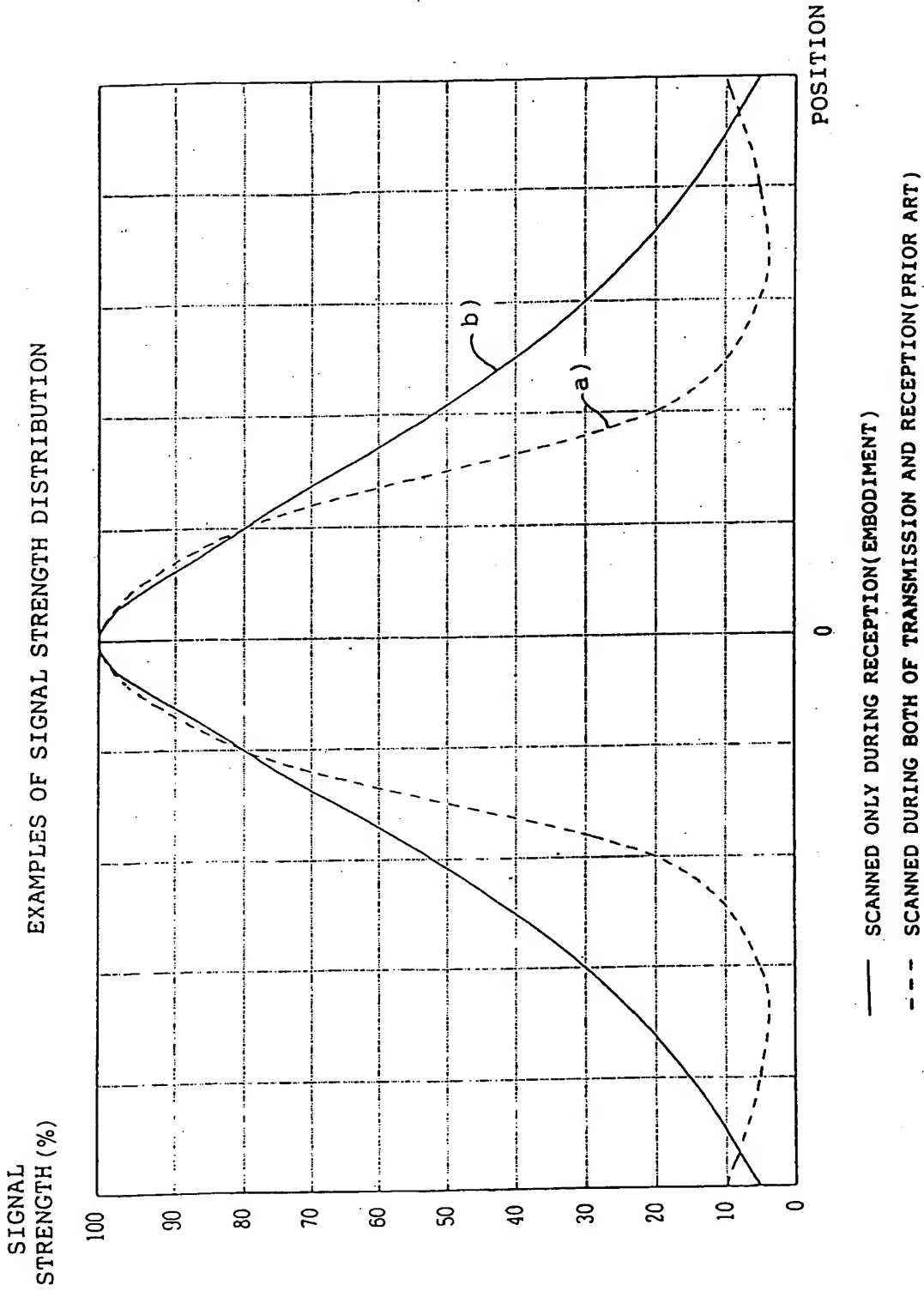


FIG. 5



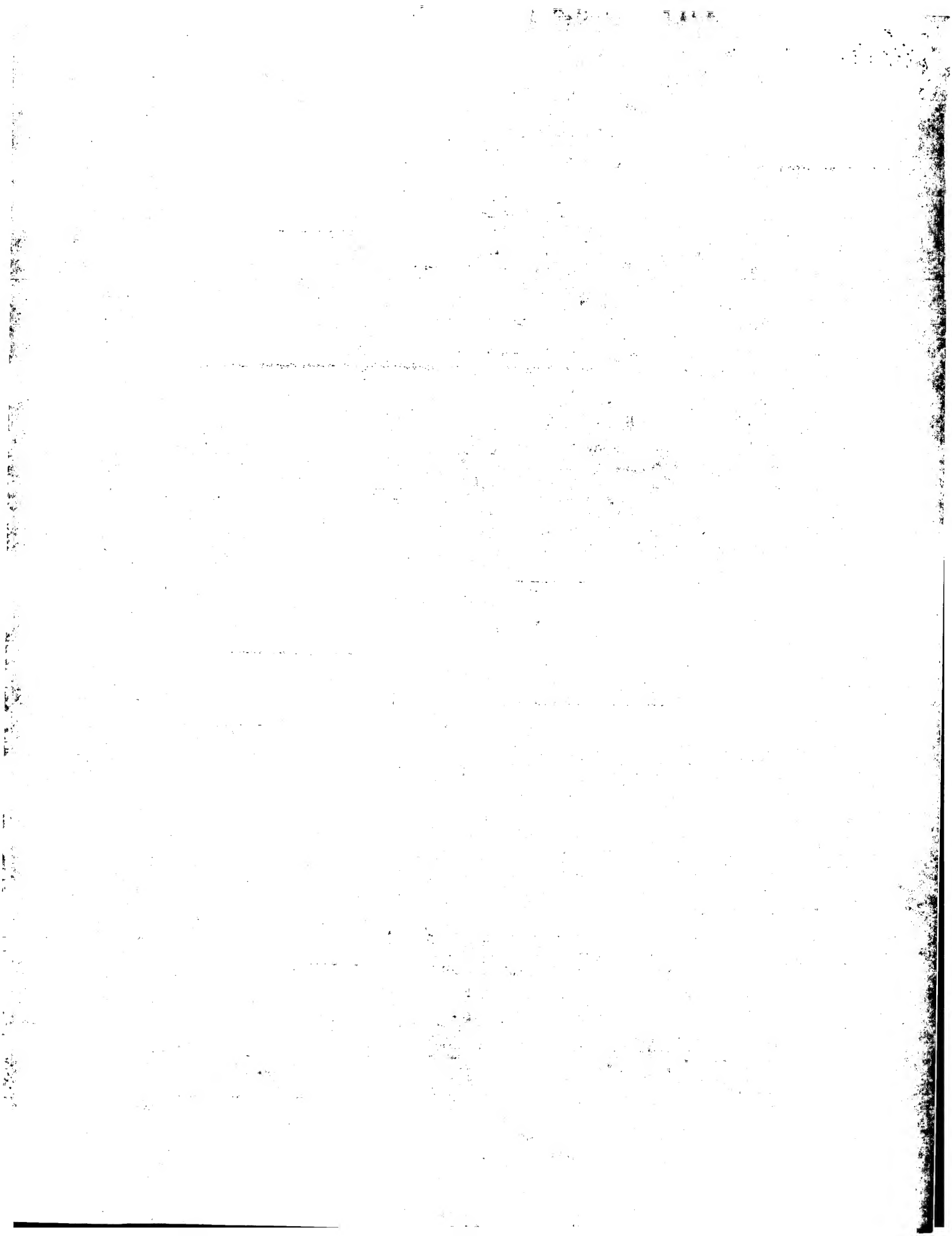
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EUROPEAN SEARCH REPORT

Application Number
EP 95 10 0477

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP-A-0 607 694 (T.D.S. CAD-GRAPHICS LTD.) * abstract; figure 1 * * column 9, line 30 - line 38 *	1,2,5,6	G06K11/16
A	EP-A-0 457 219 (SEIKO INSTRUMENTS INC.) * abstract; figures 1,8 *	1,2,5,6	
A	EP-A-0 565 852 (I.B.M. CORP.) * abstract; figure 1 *	1	
A	EP-A-0 259 894 (WACOM COMPANY, LTD.) * the whole document *		
D	& JP-B-02 053 805 (WACOM COMPANY, LTD.)		
A	EP-A-0 499 641 (WACOM CO., LTD.) * the whole document *		
D	& JP-A-03 147 012 (WACOM CO., LTD.)		
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			G06K
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 11 March 1996	Examiner Danielidis, S
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
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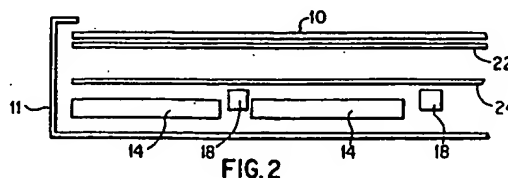
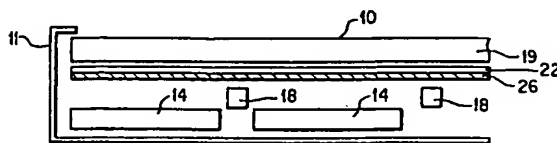
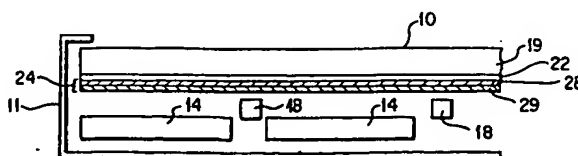
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W-7000 Stuttgart 80 (DE)(54) **Shielding materials for electromagnetic digitizers.**

(57) Shielding materials used in electromagnetic digitizers which are packaged in a notebook computer environment. Shielding materials with sufficiently high magnetic permeability to increase the magnetic signal detected by the digitizer sensor grid (22) can be used in such an environment, and can be placed in direct contact with the sensor grid. Aluminum or copper shields (26 or 24) can also be placed in direct contact with the sensor grid to provide the requisite shielding. A combination of conductive and ferrite material can also be used as the conductive base material (29) provides for shielding and a layer of ferrite material (28) increases the magnetic signal and prevents signal attenuation by the conductor.

**FIG. 2****FIG. 3****FIG. 4**

The present invention relates generally to electromagnetic digitizers. More particularly, the present invention relates to shielding materials used in electromagnetic digitizers which are packaged in a notebook computer environment.

The present invention relates to shielding materials used in electromagnetic digitizers. Digitizers of this type use a sensor grid to electromagnetically determine the coordinates of a point designated with a stylus or pen. Shielding from the magnetic distortions and disturbances emanating from the external environment is desirable in such a device. Conductive material normally acts as a shield, but results in attenuation or loss of signal. The signal attenuation can be counteracted by use of a spacer or gap between the sensor grid and conductive shield plate, or by use of a conductive material which is also highly magnetic. The magnetic characteristic of the material serves to enhance the signal.

Conventional digitizers have used materials such as iron, steel, or aluminum as the shield, and located the planar shield several millimeters below the sensor grid to isolate the sensor from the external environment. One product uses a silicon steel which causes much less attenuation of the signal than the above-mentioned materials. Some have no shield, and are susceptible to changes in accuracy and noise when placed on different surfaces.

When a digitizer is packaged over (or might be placed over) other system components (e.g., operational circuitry, including transformers and ground planes, and metallic structural elements) which include areas of high conductivity or ferrous materials, it is necessary to place a shield material between these system components and the sensor grid to prevent distortions to the detected magnetic pen signal. However, in conventional digitizers, placing a shield of conductive material too close to the sensor grid would result in attenuation of the magnetic field from the pen because of eddy currents induced in the conductive sheet. The eddy currents produce magnetic fields which partially cancel the fields from the pen. The signal cancellation increases as the conductive shield is brought closer to the sensor grid, and the signal is almost completely eliminated if the sensor grid loops are placed directly on top of the shield plate. This requires a gap or spacer between the sensor grid and shield plate. The variation of the attenuation with distance between the sensor grid and the shield plate places a constraint on the tolerance of the spacing, which can lead to increased manufacturing costs, depending on the method chosen to maintain the spacing. If this tolerance becomes too large, inaccuracies in the digitizer tablet data will result.

When a conductive shield such as aluminum is placed 0.5 mm behind the sensor grid in a conventional digitizer configuration (with 1 cm wide grid loops, and the pen coil located 2.0 cm above the grid), the signal voltage is reduced to about 10% of the signal without any shield. The signal power is thus reduced 100-fold (20 dB). The attenuation problem resulting from placing the shield in close proximity or in contact with the sensor grid can be reduced, however, through choice of the material used for the shield. In U.S. Patent No. 4,956,526, the material chosen was a silicon steel composed of 4.0 to 7.0 weight percent of silicon. When a shield of this specific composition is configured in contact with the sensor grid, the voltage magnitude of the detection signal is maintained above the minimum required to operate the digitizer. Although the sensor grid and the silicon steel shield can be in contact, there is still signal attenuation as demonstrated by the increase in signal voltage as the distance between the sensor grid and the silicon steel shielding plate increases.

Placing a digitizer in a notebook computer environment presents further problems not solved through the use of shielding materials and configurations of conventional digitizers. Packaging the digitizer in this manner exacerbates the space and weight problems for the shield materials. Without shielding, the magnetic field from the pen is distorted by eddy currents and induced magnetic fields in metallic and ferromagnetic materials in circuitry and structural members. Further, the operational circuitry may produce independent magnetic fields which are picked up in the sensor grid and appear as noise to the digitizer circuitry, reducing accuracy and resolution. To address all of these constraints, the shield must isolate the sensor grid from distortion and noise sources below the digitizer, must not itself significantly degrade the digitizer performance, and must be lightweight and compact. It is additionally advantageous if the shield material can be formed to fit around obstacles in the periphery of the digitizer, to isolate the grid from irregularly shaped interference sources outside the active area.

Within this framework, it becomes apparent that the use of aluminum or copper with a spacer takes up too much space for the packaging environment envisioned for the present invention. The use of silicon steel as a shield in contact with the sensor grid does not completely solve the packaging problems as a fairly thick shield is required which takes up space and adds weight, and the silicon steel does have an attenuating effect. Further, silicon steel is rather brittle and will not conform as easily to different shapes.

The present invention is directed to shielding materials used in electromagnetic digitizers which

are packaged in a notebook computer environment.

The first aspect of the invention is directed to shielding materials with sufficiently high magnetic permeability to increase the magnetic signal detected by the digitizer sensor grid. The shielding material can be conductive, in which case the product of the magnetic permeability and skin depth of the conductive shield must be greater than the width of the loops in the sensor grid. If the shielding material is non-conductive, then the product of the magnetic permeability and the thickness of the non-conducting shield must be greater than the width of the loops in the sensor grid. A shield made of such a material can be configured in direct contact with the sensor grid. Ferrites and Mumetal are two materials with sufficiently high magnetic permeability to increase the magnetic signal.

In one variation, a combination of conductive and ferrite materials may be used for the shield. The first layer beneath the grid is composed of ferrite material which terminates, but does not attenuate, the magnetic signal. Below this is placed a conductive layer which cancels AC magnetic fields from below the sensor grid, to prevent possible saturation of the ferrite material by those fields. With the proper selection and thicknesses of the conductive and ferrite materials, the shield plate would prevent penetration of the magnetic fields without causing attenuation. In fact, the signal voltage can be doubled by an appropriate layer of ferrite in contact with the sensor grid.

Some materials alone can both increase the magnetic signal and prevent penetration of the shield by the magnetic fields emanating from the operational circuitry and metallic structural elements. Mumetal is one such material and is characterized by increasing the magnetic detection signal, and by preventing penetration of the shield by the magnetic fields emanating from the operational circuitry and metallic structural elements.

In a third aspect of the invention, a conductor, such as aluminum or copper, is placed in close proximity to the sensor grid to provide shielding primarily from disturbances emanating from the operational circuitry and metallic structural elements of the digitizer. The aluminum or copper shields can be placed as close as 0.5mm from the sensor grid and still allow sufficient signal strength, while providing the desired shielding.

The foregoing and other objects, features, and advantages of the present invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings.

The invention will be better understood if reference is made to the accompanying drawings in which:

FIGURE 1 is a cross-sectional view, not to scale, of an electromagnetic digitizer showing the general relation of the sensor grid, the shield plate, and the internal and external sources of interfering magnetic fields;

FIGURE 2 is a simplified cross-sectional view, not to scale, of an electromagnetic digitizer which shows the use of a wide space between the sensor grid and the shield plate;

FIGURE 3 is a simplified cross-sectional view, not to scale, of an electromagnetic digitizer with a high magnetic permeability shield;

FIGURE 4 is a simplified cross-sectional view, not to scale, of an electromagnetic digitizer with a shield plate comprised of ferrite and conductive material;

FIGURE 5 is a simplified cross-sectional view, not to scale, of an electromagnetic digitizer with a conductive shield closely spaced with the sensor grid substrate; and

FIGURE 6 is a simplified perspective view, not to scale, of the components of a sensor grid in contact with a conductive shield plate.

FIGURE 1 is a cross-sectional view of an electromagnetic digitizer assembly as might be configured in a notebook computer environment, and includes a liquid crystal (LCD) or other display 12 and backlight 13 for display of the data. The pen or stylus 16, which includes a magnetic coil 17, is used to designate or input the desired point on the writing surface 10 through detection of an electromagnetic signal by the sensor grid 22. The operational circuitry shown generally at 14 calculates the coordinate value for the designated point. The electrostatic shield 15 isolates the sensor grid 22 from electrostatic noise generated by the LCD 12 or backlight 13. All components disposed between the sensor grid 22 and the writing surface 10, including the display 12, backlight 13, and electrostatic shield 15, are shown collectively at 19. The shield plate 24 provides shielding from the internal sources of distortion or interfering magnetic fields, and, in the case of purely conducting shields, provides some reduction of noise from external sources. The internal sources of interference include the operational circuitry 14 and conductive or ferromagnetic material 18, such as transformers, ground planes, and metallic structural elements. The external sources of interference are represented in FIGURE 1 by the source 20. One example of an electromagnetic digitizer in which the shielding materials of the present invention can be used is described in U.S. Patent Application Serial No. 07/696,434, filed May 6, 1991, which is herein incorporated by reference. The cited application incorporated by reference and the present application have a common assignee.

FIGURE 2 is a cross-sectional view of an electromagnetic digitizer with a conventional desktop digitizer structure. The digitizer is enclosed in a case 11 and includes operational circuitry 14 and conductive or ferromagnetic materials 18 (e.g., metallic structural elements). The shield plate 24 is shown disposed below the sensor grid 22 with a wide gap or space between these two components. In most conventional desktop digitizers, there is also a space between the sensor grid 22 and the writing surface 10, as shown in FIGURE 2.

FIGURE 3 is a cross-sectional view of an electromagnetic digitizer as might be configured for packaging in a notebook computer environment. A digitizer in this configuration includes a case 11, operational circuitry 14, and conductive or ferromagnetic materials 18 as does the conventional desktop configuration. However, this configuration includes components, shown collectively at 19, disposed between the writing surface 10 and the sensor grid 22. The components shown collectively at 19 include the display 12, backlight 13, and electrostatic shield 15, as shown in FIGURE 1. The shield plate 26 as shown in the configuration of FIGURE 3 is comprised of a highly magnetic material, that is, a material with a high magnetic permeability.

The shielding configuration shown in FIGURE 4 might also be used when packaging the digitizer in a notebook computer environment. A shield plate 24, shown disposed below the sensor grid 22, is comprised of conductive material 29 with a layer of magnetic material 28 disposed on the upper surface of the conductor 29.

FIGURE 5 illustrates another alternative shielding configuration. The components of the sensor grid 22 are shown to illustrate the configuration of the wire loops 23 and the sensor grid substrate 21. The configuration of the wire loops within the sensor grid is shown in more detail in FIGURE 6. The conductive shield 30 is shown in contact with the sensor grid substrate 21. The conductive shield provides shielding from magnetic disturbances emanating primarily from the system components within the electromagnetic digitizer but also from the external environment 20. When the shield is placed between the operational circuitry and the sensor grid, it will provide the greatest degree of shielding from the magnetic fields emanating from the operational circuitry 14 and the conductive and magnetic material 18, but will also result indirectly in attenuation of magnetic fields emanating from the other side of the sensor grid (i.e., where the pen is held).

FIGURE 6 is a perspective view showing the components of the sensor grid in contact with the conductive shield plate 30. As shown in FIGURE 5, the sensor grid 22 comprises wire loops 23 and

sensor grid substrate 21. As shown in FIGURE 6, the wire loops 23 are comprised of pairs of wires 27. The wire loops form the closed path around which the signal voltage is produced by the magnetic induction from the pen coil 17. The loops may be comprised of any conducting material and may be either permanent or temporary. Permanent loops are formed by physically continuous connections of the wire pairs 27. Temporary loops are formed by selecting various wires 27 to form a pair through use of electronic switches. The width of the permanent loops would therefore be fixed, while the width of the temporary loops might vary, depending upon which two wires were selected to form the loop. For clarity, only one set of loops is shown in FIGURE 6. Another set of loops, perpendicular to the set shown in FIGURE 6, would be required to determine the other coordinate of the designated point.

A shield comprised of a highly magnetic material, as illustrated in FIGURE 3, performs not only the shielding function but also avoids the loss of signal encountered when using a simple conductive material as a shield. A material with sufficiently high magnetic permeability can actually double the magnetic signal in the sensor grid. When there is a change in the magnetic lines of force (i.e., a change in the magnetic flux), an electromotive force is produced in the conductor through the principle of electromagnetic induction. The current in the pen coil 17 is pulsed or sinusoidally varying in time, in order to induce signal voltage in the loops of the sensor grid; it also induces current in any conducting shield plate. Magnetic permeability is a factor, characteristic of a material, that is proportional to the magnetic induction, (magnetic flux density) produced in a material divided by the magnetic field strength (vector quantity characterizing the magnetic field). This relative permeability varies with the magnetic field strength and associated flux density.

How good the material is at increasing the signal strength of the magnetic field may be seen by comparing the product of skin depth and magnetic permeability with the width of the loops in the sensor grid. Skin depth is the depth beneath the surface of a conductor, which is carrying current at a given frequency due to electromagnetic waves incident on its surface, at which the current density drops by a factor of e (2.718) below the current density at the surface. To enhance the signal strength of the magnetic field, the product of the permeability and the skin depth of the conducting material should be greater than the width of the loops in the sensor grid. If the magnetic material is not conducting, then the product of the permeability and thickness of the magnetic layer should be greater than the width of the loops in the sensor

grid.

One such material of high magnetic permeability which increases the signal strength of the magnetic field is Mumetal. Mumetal is a nickel alloy comprising approximately 5% copper, 2% chromium, 77% nickel, and 16% iron. Mumetal has an initial permeability of 20,000 and a maximum permeability of 100,000. Mumetal is light weight, and sufficiently soft (malleable) to allow shaping or fastening at the edges, as may be required by the packaging environment. In addition to increasing the signal strength, it also prevents penetration of the magnetic field.

Iron-oxide/metal-oxide ceramics (ferrites) also have high magnetic permeability and could be effectively used as a shield material to increase the signal strength.

In another embodiment, a combination of conductive and ferrite materials may be used for the shield. This is illustrated in FIGURE 4 which shows a shield plate 24 comprised of magnetic material 28, such as ferrites, with a layer of conductive material 29, such as copper, disposed on the lower surface of the magnetic material, in contact with the sensor grid 22. The first layer beneath the sensor grid is composed of ferrite material which terminates, but does not attenuate, the magnetic signal. Below this is placed a conductive layer which cancels AC magnetic fields from below the sensor grid, to prevent possible saturation of the ferrite material by those fields. For example, a layer of ferrite material of appropriate thickness and composition to cancel the attenuation effect could be disposed on top of a copper sheet (1 mil thickness for 500 KHz field) which effectively shields alternating current (AC) magnetic fields. This is helpful in reducing magnetic noise from sources below the sensor grid which might otherwise saturate the highly magnetic layer.

It should also be noted that shields made from Mumetal or a conductive material with a layer of ferrite material have the added advantage of relaxing the tolerance requirements for any separation between the shield plate 24 and the sensor grid 22, as compared with purely conductive or silicon steel shields.

A material such as Mumetal which will increase the signal strength of the magnetic field is relatively expensive for use in this application. An inexpensive alternative is to place a sheet of conductive material such as aluminum or copper below and in close proximity to the sensor grid to act as a shield. The shield's conductivity and thickness must be sufficient so that the eddy currents induced in the conductor effectively terminate the perpendicular component of the pen's magnetic field, preventing it from penetrating significantly below the shield. This is achieved if the skin-depth

(s) and thickness (t) of the shield satisfy the relationship;

$$t \gg (s^2)/h$$

where h is the height of the pen coil above the sensor grid. For example, copper has a skin depth of about 0.08 mm at 500 KHz, so, with the pen coil 2 cm above the sensor grid, a copper shield would have to be much greater than (.08 mm*.08mm/20mm), which is 0.32 microns. Thus a sheet of copper of at least five to ten microns thickness would be desirable. A simple experiment with a 2 micron copper sheet shows about 10:1 attenuation of the signal below the sheet from a pen coil 2 cm above the sheet, verifying the calculated requirement, and suggesting that 10 microns would probably be required for thorough (99% effective) shielding.

In such a configuration with use of a conductive shield, "close proximity" should be construed as approximately one millimeter or less spacing between the shield and the plane of the sensor grid loops. At a separation of 0.5 mm, with the pen coil 1.5 cm above the sensor grid, and using 1 cm wide sensor grid loops, the induced signal voltage in the sensor grid loops is attenuated to approximately one tenth (10%) of the signal voltage without a shield. Thus, in order to maintain operability of the digitizer with such a shield, the detection electronics need to be improved to provide an extra 20 dB of gain, or, alternatively, the inducing current in the pen coil 17 may be increased 10-fold, if sufficient power is available. By placing the conductive shield plate 30 in contact with the sensor grid substrate 21 as shown in FIGURE 5, the need for the space between the sensor grid 22 and shield plate 24 as shown in FIGURE 2 is eliminated. This saves space and weight which are of particular importance in this packaging environment.

The use of copper in close proximity to the sensor grid has the added benefit of stronger attenuation of alternating fields above the grid for distant radiation sources 20 (such as CRT's, lights, or transformers) than for near sources (such as the digitizer pen or stylus 16). This can often result in increased signal to noise ratio in the detected signal.

While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example, and not limitation. Thus the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents. It will be understood by those skilled in the art that various changes in form and detail may be

made therein without departing from the spirit and scope of the invention.

Claims

1. An electromagnetic digitizer, comprising:
a sensor grid, and a shield plate disposed
under said sensor grid,
wherein said shield plate comprises a material
with sufficiently high magnetic permeability to
increase the magnetic signal in said sensor
grid.
 2. An electromagnetic digitizer according to claim
1, wherein
said sensor grid comprises a multiplicity of
wires such that said wires form loops, and
wherein said shield plate comprises a conduc-
tive material and the product of the magnetic
permeability and skin depth of said conductive
material is greater than the width of said loops
in said sensor grid.
 3. An electromagnetic digitizer according to claim
1, wherein
said sensor grid comprises a multiplicity of
wires such that said wires form loops, and
wherein said shield plate comprises a non-
conductive material and the product of the
magnetic permeability and the thickness of
said non-conductive material is greater than
the width of said loops in said sensor grid.
 4. An electromagnetic digitizer according to claim
1, wherein
said sensor grid includes a sensor grid sub-
strate; and said shield plate is in direct contact
with said sensor grid substrate.
 5. An electromagnetic digitizer, comprising:
a sensor grid comprising a multiplicity of wires,
a pen comprising a pen coil, and a shield plate
disposed under said sensor grid, wherein
said shield plate comprises conductive ma-
terial such that said conductive material is of
sufficient thickness and conductivity to prevent
penetration of the magnetic field of said pen
coil, said shield plate being in close proximity
to said wires of said sensor grid.
 6. An electromagnetic digitizer according to claim
5, wherein
the separation between said shield plate and
said wires of said sensor grid is one millimeter
or less.
 7. An electromagnetic digitizer according to claim
5, wherein
- said sensor grid further comprises a sensor
grid substrate and the separation between said
shield plate and said wires of said sensor grid
is provided by said sensor grid substrate.
8. An electromagnetic digitizer, comprising:
a shield plate disposed under a sensor grid,
wherein said shield plate comprises a base
material of conductive material with a layer of
magnetic material disposed on one side of
said base material.
 9. An electromagnetic digitizer according to claim
1 or 4 or 8, wherein said shield plate com-
prises ferrites.
 10. An electromagnetic digitizer according to claim
5 or 7 or 8, wherein
said shield plate comprises copper.
 11. An electromagnetic digitizer according to claim
5 or 8, wherein said shield plate comprises
aluminum.
 12. An electromagnetic digitizer, comprising:
a shield plate disposed under a sensor grid,
wherein said shield plate comprises a material
that increases the magnetic signal in said sen-
sor grid and which prevents penetration of
magnetic fields.
 13. An electromagnetic digitizer according to claim
12, wherein
said shield material comprises a Nickel alloy.
 14. An electromagnetic digitizer according to claim
1 or 4 or 12, wherein
said shield plate comprises Mumetal.

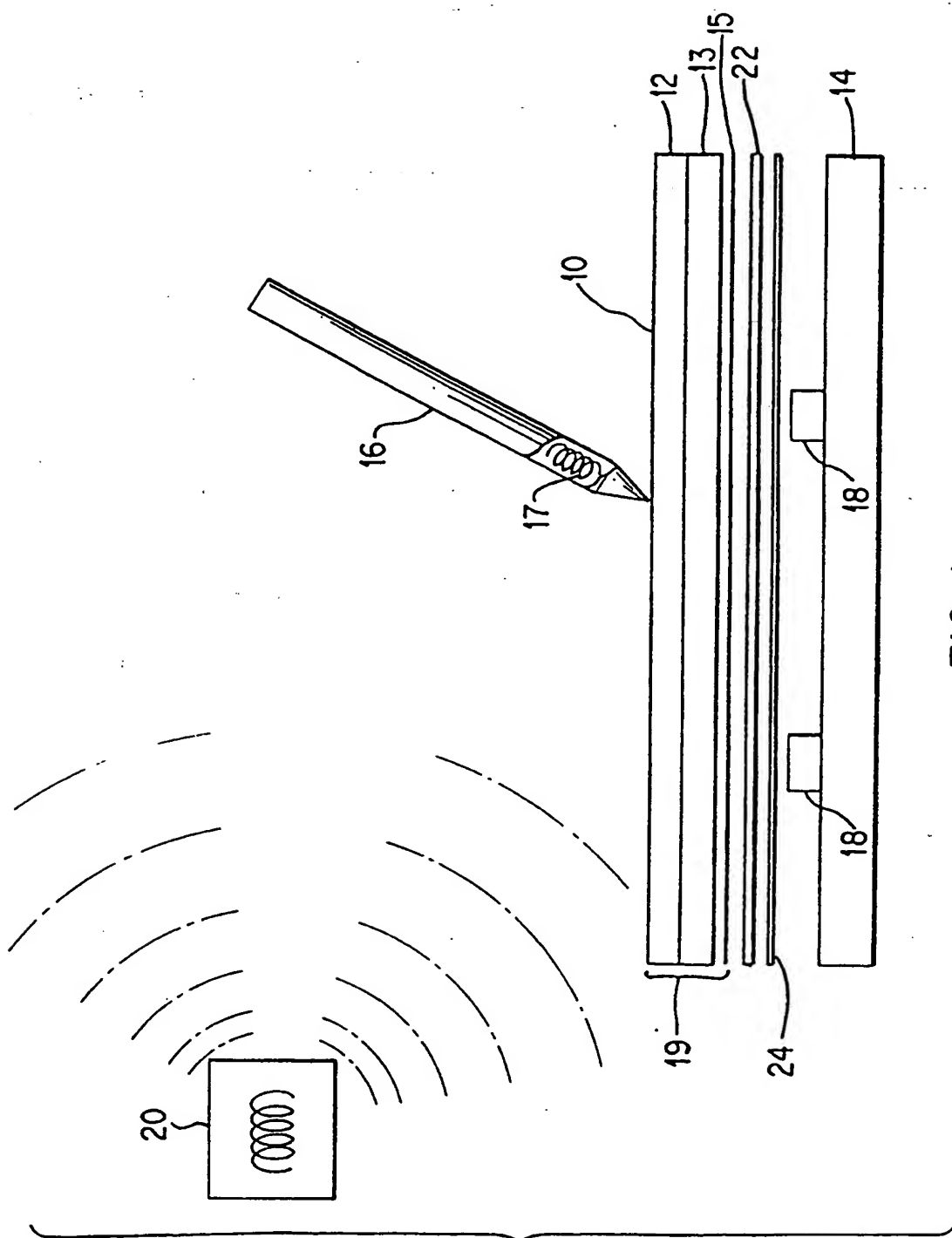
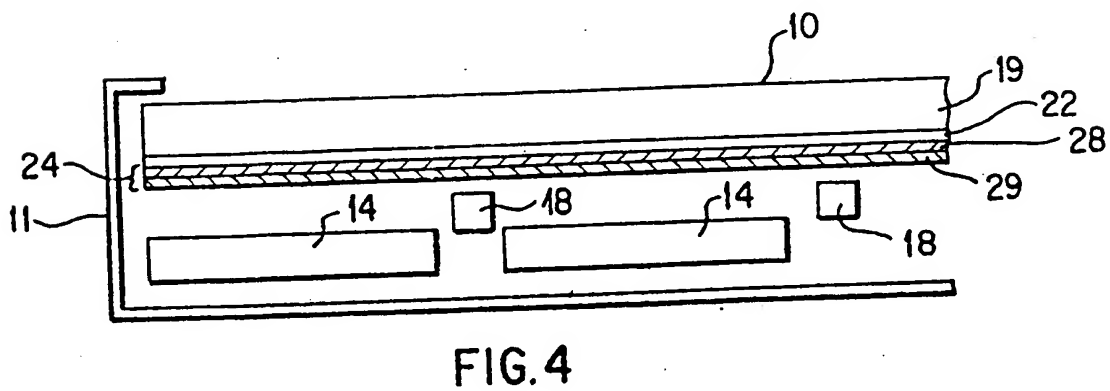
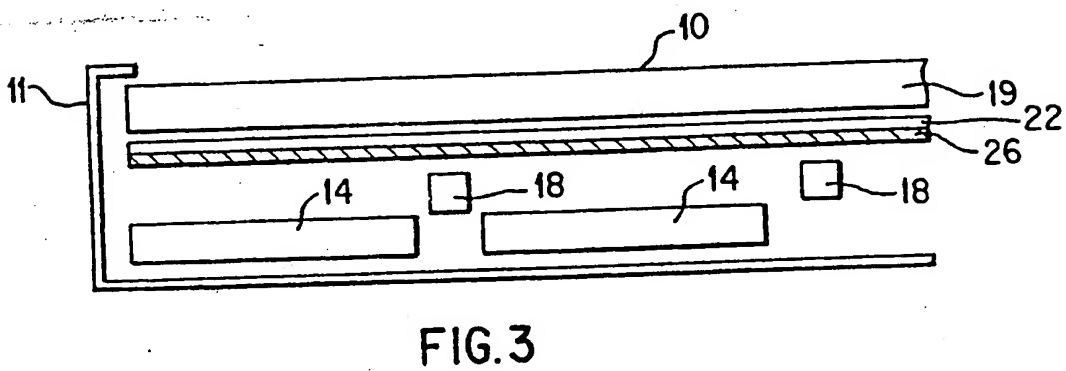
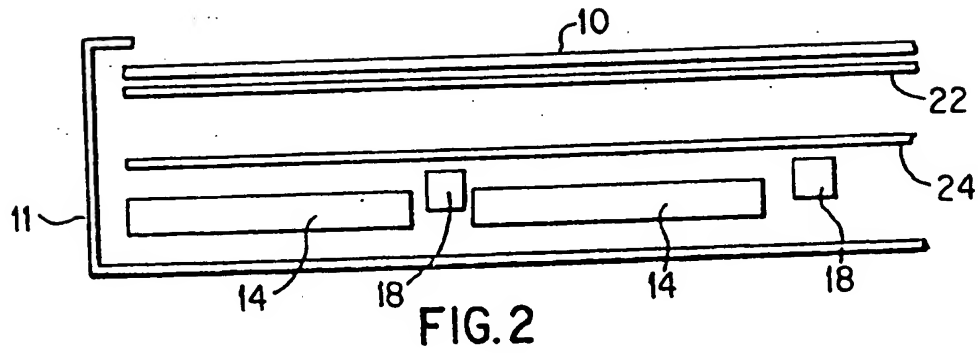


FIG. 1



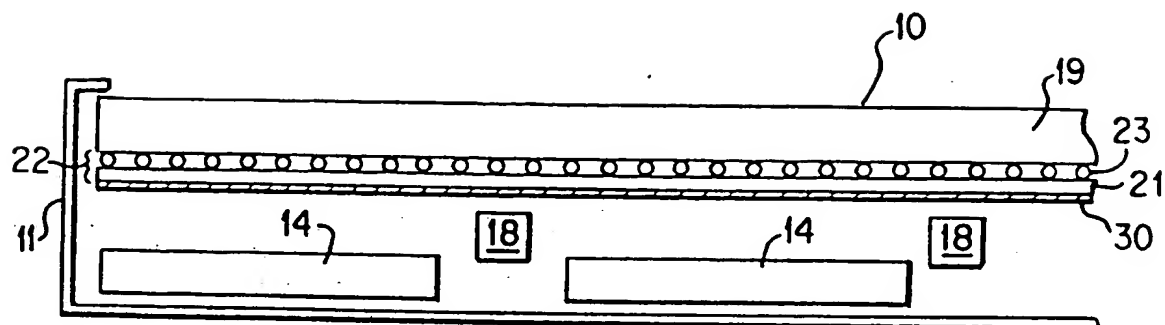


FIG. 5

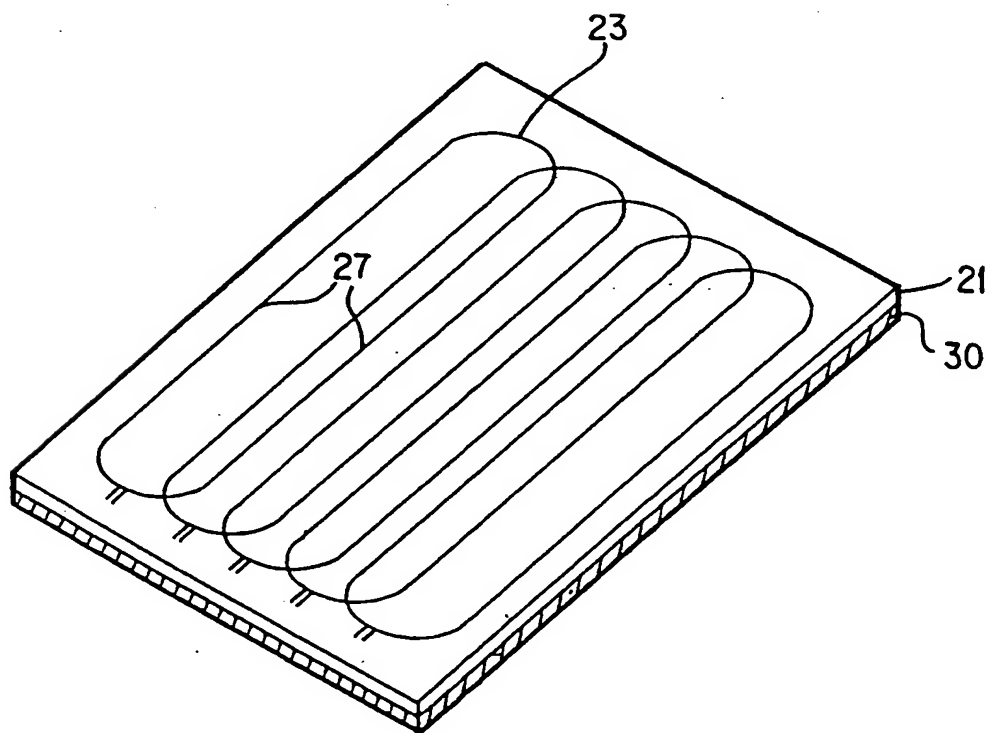


FIG. 6



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 11 4872

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. CL.5)
A	PATENT ABSTRACTS OF JAPAN vol. 13, no. 342 (P-908)2 August 1989 & JP-A-11 02 622 (SHARP CORPORATION) * abstract *	1,5,8,9, 12	G06K11/16
A	US-A-4 853 497 (WALDO L. LANDMEIER) * column 1, line 38 - column 2, line 25; figure 4 *	1,2,5,8, 11	
A	US-A-4 497 977 (YASUHIRO SAITO ET AL.) * column 2, line 32 - column 4, line 8 *	1,5,8	
			TECHNICAL FIELDS SEARCHED (Int. CL.5)
			G06K G06F
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 29 OCTOBER 1992	Examiner ALONSO Y GOICOLEA L.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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